This project improves the control mechanisms for a semi-autonomous wheelchair with an assistive robotic arm system, also known as Anna. The system is aimed at increasing the self-sufficiency of individuals with Lock-in Syndrome (LIS). The objectives of this project include the validation of the existing control interfaces, as well as the integration and design of new systems. The wireless brain-computer headset, used to implement the control system for wheelchair navigation, is validated through several user studies. An Electromyography (EMG) sensor system serves as an alternative control module for wheelchair navigation. To increase physical interaction with the environment through object manipulation, a 6 degree-of-freedom robotic arm system is integrated with Anna. The arm system includes a RGB-D camera for object detection and localization, enabling autonomous object retrieval to enable self-feeding. The project outcomes include a demonstration of Anna in various conditions performing navigation and manipulation tasks.

**EPOC EMOTIV HEADSET**
- EPOC Emotiv Headset measures and classifies electrical muscle activity caused by different facial expressions using Electromyography
- Data from 30 human trials used to determine optimal facial expressions for system control
- Switches between wheelchair navigation, arm system control, and passive modes
- Identified commands to control 5 degrees of freedom in each mode
- Command detection accuracy of 85% and 4% false command detection

**SYSTEM CONTROL ARCHITECTURE**

**ANNA**
- 6 degree-of-freedom Kinova Robotics Jaco arm
- Manual and autonomous end effector control
- 0.90m workspace, 2kg weight limit
- Calculates a kinematic chain using the KDL plug-in
- Capable of static path-planning
- Using x,y,z point and orientation input from camera, calculates a goal angle for each joint
- Plans a series of trajectories to the goal, simplifies the plan, and executes trajectory
- Image segmentation with ASUS XTION Pro Live
- RGB-D camera, 0.8m to 3.5m range
- Extracts object point cloud for objects on horizontal surfaces (e.g. table or counter top)
- Calculates approximate centroid of each object
- Determines pose of object wrt wheelchair base

**OUTCOMES**

**Emotiv Headset**
Created a multi-modal system with 5 degrees of freedom and an 85% command accuracy

**EMG Module**
Converted muscle signals to logic high pulses for wheelchair navigation

**Robotic Arm**
Preformed object retrieval with the use of static path-planning and object avoidance

**Vision System**
Performed image segmentation to extract object centroid and pose

**ELECTROMYOGRAPHY (EMG) MODULE**
- EMG module measures electrical neck or arm muscle activity
- Module converts muscle signal to a logic high pulse
- Two stage amplifier circuit amplifies electrical activity
- Module can detect finger movement dependent upon forearm location

**ACKNOWLEDGEMENTS**
Robert Boisse
Velin Dimitrov
Nick Cebry
David Kent
Russell Toris

This material is based upon work supported by the National Science Foundation under Grant No. 1135854